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TOWARDS A SIMULATION AND VISUALIZATION PORTAL TO SUPPORT MULTI-ACTOR DECISION MAKING IN MAINPORTS

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ABSTRACT

Decision makers in ports and airports are working in an extremely complex environment. Decisions involve multiple actors, who all have a different view on the system under investigation, and on the effectiveness and desirability of possible outcomes of the decision making process. Simulation and visualization are two core technologies to support these complex decision making processes. One of the major challenges is to provide the variety of involved actors with visualizations that fit their view on the system. Two case studies show that the visualizations should be able to provide two views on decision making: a view on the system under investigation and a view on the multi-actor decision making process itself. This paper presents the requirements for a service-oriented and web-based simulation and visualization portal, which integrates both views. In cooperation with the Port of Rotterdam we are currently developing and testing a prototype implementation of the portal.

1 INTRODUCTION

Ports and airports are complex organizations in a complex environment. This is especially the case when the ports and airports function as an important transportation hub – we call them a "mainport" in these cases – because of their substantial economical, political and social influence on a region. Because of the high population density we often see in the vicinity of mainports and the effects of mainports on their surroundings, decision making in these organizations is extremely complex. These effects are, by the way, both positive, e.g., employment and income, and negative, e.g., sound and pollution. Usually, the effects of the decisions reach far outside the boundaries of the organization. Many external actors therefore interfere with the decision making processes, as providers of information, as receivers of information, or as a decision maker.

One of the major problems with decision making in these "multi-actor" contexts is that the view of each actor on the system is different. This means that our models, modeling methodologies and visualizations should be geared to multi-actor use, where the way the actors use the models and visualizations can be very diverse.

A fruitful approach to dealing with these complex and ill-structured problems is to apply simulation as a method of inquiry (Churchman 1971; Sol 1982). We consider visualization as a means to make the outcomes of simulation as a method of inquiry accessible and understandable to the involved actors. A score of possibilities to visualize data exists (Tufte 1998) and choosing the right visualization method to support the decision making processes is far from trivial. Software technology used to be a limiting factor for some of the visualizations, but with growing computer power and developments in the field of computer graphics, it is now easier than ever to provide powerful visualizations to the involved actors (Strothotte and Strothotte 1997; Bederson and Shneiderman 2003).

As a result the challenge of simulation and visualization lies not so much in how to provide advanced computer graphics. Instead, the main challenge is how to provide the wide variety of involved actors with visualizations that fit their view on the problem, their knowledge, their expertise and their information needs. We consider advances in (web-)portal technologies as a possibility to meet this challenge.

In section 2 we explain the potential benefits of a simulation and visualization portal. We conducted a number of case studies, which we describe in section 3. From our findings in these case studies we deduct the requirements, which the simulation and visualization portal should meet in section 4. Finally we describe our first experiences and future planning in section 5.

2 A SIMULATION AND VISUALIZATION PORTAL

Carlsson and Turban (2003) stress the role of new intelligent software systems to deal with the overwhelming flow of data and information produced in complex decision making processes. We see the possible benefits of using state of the art web technologies to support multi-actor decision making at mainports. These complex decision making processes usually take month of work, involve a large number of actors from a wide variety of domains and are information intensive. We consider personalization of the way in which actors interact with simulation and visualization as a major challenge. Considering the time-span and the amount of information it is important that the involved actors are able to keep track of the decision making process: e.g., who did what, what information is available, the status of information, what was decided and so on.

We consider a portal as the enabling technology. Abdernur and Hepper (2003) define a portal as: "a web based application that -commonly- provides personalization, single sign on, content aggregation from different sources and hosts the presentation layer of Information Systems" (page 13). Boyson et al. (2004) describe the use of portals in real-time supply chain management. They mention similar functionalities as Abdernur and Hepper, but also mention the role of a portal as an "Internet-based hub of information and services accessible through a variety of devices…" (page 118).

A simulation and visualization portal is a portal specifically aimed at providing a suite of simulation and visualization services. When a user, an actor involved in a decision making process, signs on then he or she is provided with a personalized web environment to interact with simulation experiments (Zeigler 2000). This web environment provides the user with a set of services, also called portlets (Abdelnur and Hepper 2003), which are specifically configured for the issues under consideration.

Executing simulation experiments in a portal requires simulation and visualization technologies that are suitable for web-based usage. Many existing simulation packages such as Arena® (Rockwell Automation, Inc.) and eM-Plant® (Tecnomatrix Technologies Ltd.) were developed as desktop applications, however recent developments show a move towards web-based simulation. For example DSOL, a java based simulation library, has successfully been applied in a number of web-based simulation projects (Jacobs 2002). These developments make it possible to really integrate simulation and visualization in a portal.

Not only is it possible to integrate simulation and visualization in a portal, but interoperability of simulation and visualization services with other portal services is now also possible, since the Java Portlet Specification (Abdelnur and Hepper 2003) provides a clear and consistent interface for portlets to ensure compatibility of services. Figure 1 shows an example of how existing off the shelf services can be combined in a portal. The possibility to integrate simulation and visualization with services for documentation, communication and administration opens new possibilities. We recognize the challenge of really supporting multi-actor decision making in mainports.

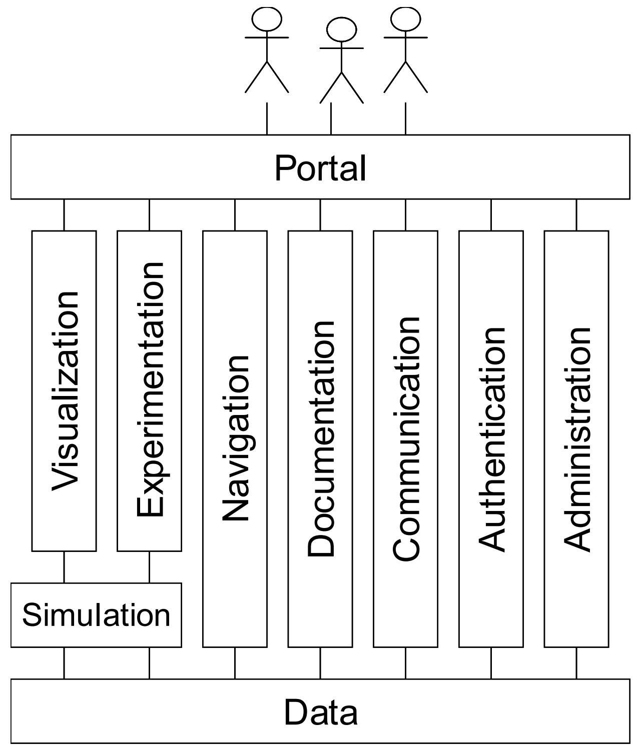

Figure 1: Example of services in a simulation and visualization portal.

3 CASE STUDIES

We did two case studies to gain insight in the problems involved in decision making and planning processes at mainports. The first case study was more explorative in nature as we did not have a clear idea of multi-actor decision support at mainports yet. From that case the first ideas for a web-based solution began to appear. The second case study is ongoing research where we really want to implement a simulation and visualization portal.

3.1 The Airport Business Suite

Our first case study was a project initiated by the Delft University of Technology in 2002 named the Airport Business Suite (ABS) (Visser et al. 2003; Roling and Wijnen 2004). This project was focused on the development of a suite of software services for airport strategic exploration. The aim was to support airport decision advisors in rehearsing future scenarios and explore options to solve the issues that emerged from these scenarios. Airport decision advisors develop a long term vision on how an airport should be developed. For example, a vision on how an airport should be developed to cope with a growing demand for flights. This could lead to the option of runway expansion, which would require insight into e.g., expected delays, safety, environmental impact and the economic effects.

The ABS aimed at providing an integral view on airport design and planning problems using both static and dynamic models. We used existing, commonly accepted models where possible. In some cases we implemented models according to existing specifications. In other cases we linked to existing model implementations. For example we used the generally accepted Integrated Noise Model (INM) (FAA 2005) to calculate aircraft noise contours, and we used the Upgraded FAA Airfield Capacity Model (Ball and Swedish 1981) to calculate the theoretic runway capacity.

Most existing models provided mono-disciplinary, or domain specific information and did not offer much freedom in providing customizable visualizations. Also the levels of abstraction differed considerably among the models, which made it difficult to provide an integral view on the situation. The ABS project was mainly technology centered, focusing on how to combine the results of different models in integral visualizations. Consequently there was less attention to investigate the specific visualization needs of airport decision advisors. It became clear to us that the technology we needed to provide customizable visualizations first needed to be developed.

3.2 Area Planning in the Port of Rotterdam

Currently we are cooperating with the Port of Rotterdam (PoR) to develop what we call a studio for area planning (Chin et al. 2005). Area planning is the process of making a spatial development plan for an area in the port region. The PoR is one of the largest ports in the world and it is situated in a region with a high population density. Consequently changes in the port region usually have long-term social, political and economic effects. During the process of area planning the involved actors analyze combinations of lots and industry types. Eventually an acceptable balance between the geographical location, accessibility, livability, safety and commercial attractiveness of a certain area should be found.

The studio will become a simulation environment based on a simulation and visualization portal. Actors are supported by state of the art visual technologies to rehearse future scenarios and explore different options. In contrast to the ABS-project, which was centered on models, in this ongoing project there is a much stronger focus on the process of decision making. We investigated the way of working of area planning teams, how these teams evolve over time, the information that they use, the roles of the actors, and the tools and models that they use. As a result this project gave us a much better insight in the functional requirements for our simulation and visualization portal.

3.3 Lessons Learned from the Case Studies

In both case studies we aimed at providing an integral view on the decision making context. Information from a wide variety of domains is combined, or layered to enable the involved actors to consider the system under investigation from different angles. Which angles are chosen depends on the problems and bottlenecks that were identified. For example, at an airport in a densely populated region, aircraft noise and road congestion can be major bottlenecks, while in other cases the focus may be on commercial aspects and employment. Each case is unique and therefore requires different views an the system under investigation. This means that visualizations should be tailored for the case being investigated.

Furthermore the typical multi-actor setting of decision making processes at mainports suggests that visualizations should be considered in a wider perspective, wider than just visualizing the outcomes of simulation models. Often simulation models are used next to analytical models, or measured data. Furthermore, detailed simulations are often done by third party organizations specialized in a specific domain. As a result the mainport organization does not have access to the simulation model itself, but only the outcomes reported by the third party. In practice these outcomes are combined with other data to provide a more integral view on the system.

Not only do actors need to be provided with different views on the system, but also data from different models needs to be combined into an integral view on the system. However, different models are based on different assumptions and boundary conditions. The involved actors must be aware of this, which raises the need for documentation support.

4 REQUIREMENTS

Based on our two case studies we extract the requirements for our simulation and visualization portal. High level requirements are described in section 4.1. They are worked out in section 4.2.

4.1 High Level Requirements

From the two case studies we can extract the high level requirements. Visualizations should be able to provide two views on decision making:

- a view on the system under investigation,
- a view on the decision making processes.

The first view on the decision context is focused on the system under investigation. Different actors have very diverse roles in the decision making process. For example actors can be in the role of a decision maker, which is a person who has decision power. Decision makers need an integral view on the system so they can evaluate and analyze the options that they have under a number of possible scenarios. Other actors can be in the role of domain experts, who have a mono-disciplinary view on the system. They typically do investigations in a specific domain, such as e.g., safety. Consequently not only the information needs of the involved actors are different, but also the way in which information should be visualized and how they want to interact with the information differs considerably.

The second view on the decision making context focuses on the decision making process itself. The decision making process is information intensive. Information is not limited to a description of the system under investigation, but also includes administrative information that describes the decision making process. As a result there are two axis of time which represent the dynamics of the system and the dynamics of the decision making process. The decision making process is an iterative process, which means that the actors go back and forth between phases such as conceptualization and solution finding as new information becomes available. Also, teams of actors work both sequential as in parallel and during the process new actors may join.

Visualizing the process of decision making means making the context of the decision making process explicit to the involved actors. Coutaz (2005) provides a vision on context aware software services in the near future, where users are provided with personalized information depending on time, place and their current role. We would like to join this vision for visualizations in the decision making context.

4.2 Requirements Worked Out

We consider visualization and simulation as core technologies to improve the effectiveness of complex decision making processes in mainports. Effectiveness can be expressed in terms of usefulness, usability and usage. Usefulness describes the added value of tools and methods to the decision making process. Usability describes the mesh between people, process and technology. And finally usage describes flexibility, adaptivity and suitability to the decision making context. (Sol and Keen 2005). In the following sections we organize the requirements for our simulation and visualization portal in terms of usefulness, usability and usage.

4.2.1 Requirements Related to Usefulness

The most important requirement regarding usefulness is that the simulation and visualization portal should provide the involved actors with personalized visualizations, which allow them to observe the system from their own perspective. Secondly, it should be possible to combine or layer information from different domains in a single integrated visualization. This enables the involved actors to see the interrelationships between information from different domains. The result of the first and the second requirement is a many to many relation between visualizations and models or other sources of information (Figure 2). Thirdly it should be possible to document the assumptions and boundary conditions to which information is subjected. This is especially important when combining information from a variety of sources. Fourthly, the simulation and visualization portal should support visualization of both the dynamics of the system under investigation and the decision making process. As a result there must be support for two axis of time representing the time interval at which the system is investigated and the time interval of the decision making process.

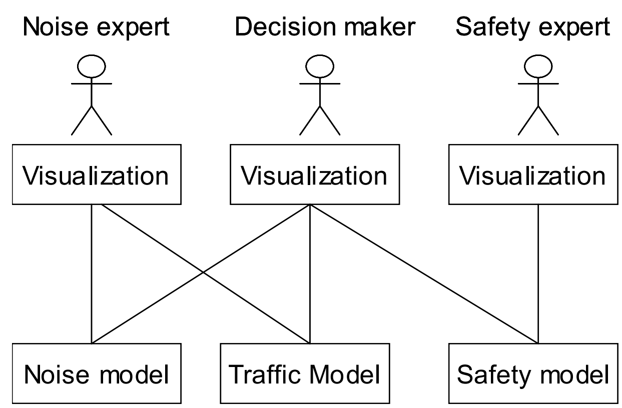

Figure 2: An example of a many to many relation between visualizations for actors and models

4.2.2 Requirements Related to Usability

Actors working sequential and in parallel suggests the need for distributed usage of simulation and visualization services. However because we started from a portal environment, this requirement is automatically fulfilled.

Actors will set up and execute multiple simulation experiments in an information intensive process, which raises the need for the ability to navigate and search through experiments and their results. Furthermore actors themselves should be able to personalize visualizations according to their personal needs. A first personalization can be achieved through defining actor roles after which further tuning should be possible for individual actors.

4.2.3 Requirements Related to Usage

Because of the uniqueness of mainport decision making processes, e.g., planning a new runway, scalability and adaptivity are major requirements for the usage of the simulation and visualization portal. Furthermore it is a requirement to link to information sources available within the organization, as a lot of information is already available within the organization. A strong integration with data sources available within the organization will make it easier to find and unlock information that is relevant to the decision making process. Furthermore information produced during this process can immediately be fed back into the organization.

5 CURRENT PROGRESS

We are currently developing a suite of simulation and visualization services to support area planning in the Port of Rotterdam (see section 3). To realize this we are developing an architecture for multiple web-based visualizations of simulation models. In line with the requirements described in section 4, this architecture should support personalized visualizations for the involved actors and provide an integral view on a number of domain specific models. We already tested some java-based implementations of visualization services using some simple models. These models were implemented in the Distributed Simulation Object Library (DSOL) developed by Jacobs (2002). After getting to a stable architecture, the next step is to make the simulation and visualization services comply with the Java Portlet Specification (Abdelnur and Hepper 2003).

6 DISCUSSION

In this paper we focused on supporting complex decision making processes at mainports by means of a simulation and visualization portal. A major challenge is to provide the involved actors with visualizations that fit their view on the system. During two case studies we found that visualizations should be able to provide two views on the decision making: a view on the system under investigation and a view on the decision making process itself. We worked out these high level requirements to a set of more specific requirements related to usefulness, usability and usage. Currently we are developing an implementation of the simulation and visualization portal in close cooperation with the Port of Rotterdam. Experts within the port reacted positively to early implementation examples. In line with the requirements they stressed the need for the possibility to configure the simulation and visualization services for different problem situations. The actors are developing multiple areas in the port region, which each have unique issues that should be investigated. Furthermore they specifically mentioned the importance of an integration with data sources that are available within the organization.

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REFERENCES

Abdelnur, A., and S. Hepper. 2003. Java™ Portlet Specification, version 1.0. Sun Microsystems. Available via <www.jcp.org/en/jsr/detail?id=168> [accessed March 17 2005].

Ball C., Wm. Swedish. 1981. Upgraded FAA Airfield Capacity Model. Federal Aviation Authorities, Washington.

Bederson, B.B, B. Shneiderman. 2003. The craft of information visualization, readings and reflections. Morgan Kaufman Publishers, San Francisco.

Boyson, S., L.H. Harrington, T.M. Corsi. 2004. In real time: managing the new supply chain. Praeger Publishers, Westport.

Carlsson C., and E. Turban. 2002. DSS: directions for the next decade. In *Decision Support Systems* 33, 105-110.

Chin, R.T.H., S.P.A. van Houten, E. Schalkwijk, J.J. Smits, P. Veenstra, A. Verbreack, and J.W. Weststrate. 2005. A decision enhancement studio for area planning in the Port of Rotterdam. Port Research Centre, Rotterdam-Delft.

Churchman, C. W. 1971. The Design of Inquiring Systems. Basic Books, New York.

Coutaz J., J.L. Crowley, S. Dobson, D. Garlan. 2005. Context is key. in *Communications of the ACM*, Volume 48, Number 3, 49-53.

FAA 2005, Integrated Noise Model. Federal Aviation Authorities. Available via <http://www.aee.faa.gov/noise/inm/> [accessed: 29 March 2005].

Jacobs P.H.M., N.A. Lang, A. Verbraeck. 2002. D-SOL; A distributed java based discrete event simulation architecture. In *Proceedings of the 2002 Winter Simulation Conference*, ed. E. Yücesan, C.-H. Chen, J. L. Snowdon, and J. M. Charnes, 793-800. San Diego, California. <http://www.informs-cs.org/wsc02papers/> [accessed April 14 2005].

Roling, P.C., and R.A.A. 2004. Wijnen. Improvements to the airport business suite: a decision support system for airport development, planning, and operations. International Conference on Research in Air Transportation, Slovakia.

Sol, H.G. 1982. Simulation in information systems development. Docteral dissertation, Rijksuniversiteit te Groningen, Groningen.

Sol, H.G., and P.W.G. Keen. 2005. Decision Support Next Generation. (forthcoming).

Strothotte, C., and T. Strothotte. 1997. Seeing between the pixels, Pictures in interactive systems. Springer, Heidelberg.

Tufte, E.R. 1992. Envisioning information. Graphics Press, Chesire, Connecticut.

Visser, H.G., R.T.H. Chin, R.A.A. Wijnen, W. E. Walker, J. Keur , U. Kohse, J. Veldhuis, and A.R.C. De Haan. 2003. The Airport Business Suite: a decision support system for airport strategic exploration. TU Delft Airport Development Center, AIAA.

Zeigler, B.P., H. Praehoffer, and T. G. Kim. 2000. Theory of modeling and simulation, second edition: integrating discrete event and continuous complex dynamic systems. Elsevier Science, San Diego.

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